ULTRASONIC SENSOR SYSTEM

REFERENCE TO RELATED APPLICATIONS

This application is related to my U.S. application Ser. No. 496,158 filed May. 19, 1983 and entitled "Efficient Low Cost Transducer System", now U.S. Pat. No. 4,530,077, and is a continuation-in-part of my application Ser. No. 727,987, filed Apr. 29, 1985 entitled "Ultrasonic Sensor System", and a continuation-in-part of application Ser. No. 748,794, filed June 26, 1985, now U.S. Pat. No. 4,654,834, entitled "Weatherproofed Ultrasonic Transducer Assembly and System Incorporating Same".

BACKGROUND DESCRIPTION OF THE PRIOR ART

Automatic door corners for swinging doors have been around for many years and there has always been a problem with respect to the swinging door striking people who get in the path of the swinging path of the door. The problem has been that in the past there has never been a presence detector that could detect the presence of a person in the area where the door is to swing open and when it is closed that ignores all other objects that are in the swinging door scene such as guard rails that are on the side, bumper on the door, for push carts and the like. Motion detectors cannot be used because when the door opens and the person stands motionless, the door can swing open and hit the motionless person which means a law suit if the person is injured. New findings regarding adverse biological effects of microwaves on the living organisms may require limiting use of microwave door systems. Basically, the only thing that has been commercially available is the rubber mat which detects somebody standing on it and it works perfectly well but has the problem, of course, that architecturally it isn't very nice, it collects dirt, has to be replaced and they are not liked. The long term cost of such mats is high and they have to be maintained, and as noted above, from time to time they have to be replaced. There are numerous radiant energy systems, such as microwave, infrared and visible light systems which provide presence or absence signals, as well as motion detection to detect approach and departure of objects. The object of the present invention is to provide a presence sensor that will detect people in the detection zone whether the door is open or the door is closed and ignore other objects which are normally in the scene such as the guard rails, the automatic door operator mechanism and the like.

The present invention is particularly applicable to automatic door opener systems for swinging doors having an automatic door operator mechanism and sensors for detecting an approaching person for whom the door is to be opened for producing a door opening signal which is coupled to the door operator to open the swinging door. According to the present invention three or more microprocessor controlled ultrasonic beam transducers project ultrasonic beams in a selected detection zone which includes the path of the swinging door and ultrasonic detector means for converting ultrasonic beam energy reflected to the beam transducers from direct and multiple path reflections to an acoustic image of objects in the selected detection zone and then this acoustical image is compared with a later acoustic image of objects in the selected detection zone. This comparison results in a correlation signal which indicates correlation permitting the door to be opened. or the lack of correlation between the first and second acoustic images to produce a signal preventing operation of the door opening device. The acoustic image in the first instance is an analog signal which is converted to the equivalent of a digital acoustical image of objects in the selected detection zone. The digital acoustic image can be converted to a first characteristic number by sampling and the second acoustic image can be converted to a second acoustic number and these two numbers compared for a lack of correlation as an indication of the presence of an unwanted object in the detection zone. This conversion includes microprocessor controlled sampling means for sampling each of the digital acoustic images at a relatively high rate to produce the characteristic number. In order to improve the probability of having a favorable aspect viewing of acoustic mirror-like targets, that is, planar acoustic reflectors that may be carried by a person, for example, a sheet of plywood or flat metal plates or glass plates into a hardware store, a second ultrasonic beam transducer projects a second beam at a predetermined angle into the selected detection zone in the path of the swinging door. Reflected ultrasonic beam energy is converted to another analog signal constituting a third acoustic image of objects in the selected detection zone. this acoustic image being compared with the one from its second acoustical image so as to provide for the electrical system "viewing" the different pathways of reflected acoustic energy from any object that may be in the selected detection zone from different angles and multiple path reflections so as to improve the probability of having a favorable aspect of viewing mirror-like targets which may be carried by persons in the selected detection zone. A central transducer is provided and oriented to acoustically view the upper central area of the selected detection zone.

In the preferred embodiment, low cost Polaroid (R) type beam transducers are utilized in conjunction with beam transformers having multiple facets as disclosed in my U.S. Pat. No. 4,530,077. In such cases, a plurality of beam angles can be closely tailored to accomodate the desired beam detection zone without inclusion of remote objects and the respective transmit receive functions of a plurality of transducers can be controlled in multiplex fashion from a single microprocessor for any sequence of transmit/receive functions.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, advantages and features of the invention will become apparent from the following specification when considered with the accompanying drawings wherein:

FIG. 1 is a top plan view of a swinging doorway for a commercial establishment showing the approach and swing sides thereof,

FIG. 2 is a side elevation view thereof,

FIG. 3 is a graph of the detected analog signal levels of one of the transducers on the swing side of the doorway plotted against time and thus constitute an analog acoustical image of the scene depicted in FIGS. 1 and 2,

FIG. 4*a* shows a digital acoustic image corresponding to the analog acoustic image shown in FIG. 3,

FIG. 4*b* is a diagramatic illustration of a sampling signal showing the manner of developing a characteristic number of the digital acoustical image shown in FIG. 4*a*,